
Generating dynamic cross-organizational process visualizations through abstract view model pattern matching

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ABSTRACT: Visualizations are a common means to perform analyses of business processes. In a collaborating environment these visualizations are based on an underlying organization-specific information model reflecting the most important entities and their interrelationships. For dynamic business processes with changing participants existing solutions apply ontologies to create an integrated information model at runtime. However, these solutions do not provide any guidance with regards to the generation of cross-organizational process visualizations originating from a dynamically integrated information model. To overcome this challenge, this paper applies pattern matching techniques between the integrated information model and abstract view models which capture the information demands for generating a specific visualization. After having motivated the topic, a conceptual model enabling the generation of ad-hoc inter-enterprise visualizations is presented. By means of an example, we further show how a pattern matching approach can be applied to create visualizations which are based on integrated arbitrary information models.

KEY WORDS: Decision support, Interactive visualizations, Business Process, Viewpoints, Arbitrary information model, Pattern matching, Data Bindings.

1. Motivation & Problem Statement

With the increasing collaboration of enterprises exploiting the advantages of Internet-provided functionalities, business processes tend to change dynamically during the execution (Bouzguenda *et al.*, 2008). The dynamic nature of a business process includes collaboration actors that are unknown at the moment of the process design. Partners can also become unavailable whilst a business process is being executed making it necessary to find services from new partners for the collaboration during runtime. As a consequence, the business process has to deal with different information models (Lee 1999) from the involved collaboration actors. Figure 1 shows an excerpt of an exemplary business process that is executed across organizational borders of several enterprises. The business process is used as a generic example for an internet value chain typical for many collaborating enterprises that utilize internet features. Every enterprise in the business process is responsible for a particular task ranging from marketing, offer and sales to post-sales services. This work assumes deviating information models between the communicating enterprises in the business process.

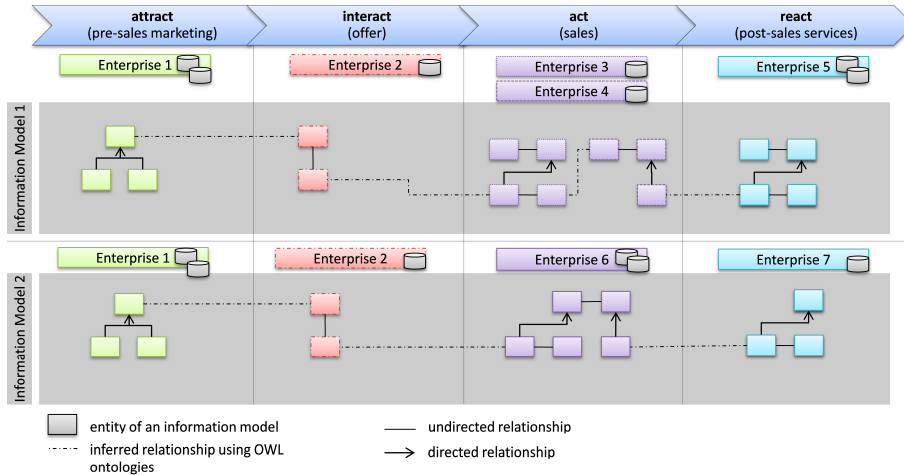


Figure 1. Ad-hoc business processes and resulting information models in Internet-enabled enterprises

Due to the different information models, every participating enterprise needs to apply domain specific ontologies to infer relationships among the models (Bouzguenda *et al.*, 2008). Purpose of these ontologies is to find suitable services by matching the metadata attributes and negotiate the communication protocols between the services. In the worst case this leads to arbitrary information models every time a process is executed with different enterprises. A potential solution

needs to address these arising integration, agility, and interoperability problems (Ullberg *et al.*, 2009) of the involved enterprises to support the visualization of arbitrary information models.

Current efforts of tool vendors in this field struggle to provide visualizations for arbitrary information models (Juli *et al.*, 2011). Since these tools use meta-models to generate visualizations from information models, it becomes unfeasible for them to handle models from varying enterprises that can have deviating business domains. In (Johnson *et al.*, 2007) a tool for enterprise architecture analysis with visualization capabilities is presented. It uses generic enterprise architecture metamodels to generate visualizations for decision makers. Although being able to instantiate enterprise independent models it is not designed for dynamic business processes with changing information models at runtime. An environment for viewpoint-support is presented in (Steen *et al.*, 2004), whereas a viewpoint defines a model abstraction for particular concerns of groups of stakeholders. This approach is focussed on the transformation of existing models, while this paper is geared towards generating visualizations from integrated information models.

2. Approach

Dynamically changing business processes are based on frequently changing arbitrary information models such that any visual analysis requires visualizations generated in an automated manner, i.e., an explicit mapping in terms of manual definitions of model transformations must be avoided. This requires an appropriate selection of information demands that need to be generic enough to be suitable for deviating models between collaboration partners. We propose a solution for this problem by applying our conceptual framework to perform the necessary model transformations for the visualization. Assuming that information models and respective data of a business process are captured by workflow engines for every enterprise collaborating in the business process, we also demonstrate how to avoid manual accommodations for varying information models.

Figure 2 shows our conceptual framework that is used to carry the mapping for generative visualizations. The data model represents a collaborating enterprise's data inside an information source, e.g., concrete business applications, business units, or employees. An information model defines the data schema of a particular data model with the concepts, relationships, constraints, rules and operations the data model needs to fulfil (Lee 1999). Based on a data model query the view data model constraints the original information and eventually creates new attributes by aggregating existing values. The underlying schema of this query is defined by the view model that 1) has to conform to the structural features of an abstract view model and 2) directly maps to the respective information model. The actual visualization consists of instantiated shapes that are summarized in the symbolic model and are defined by the visualization model.

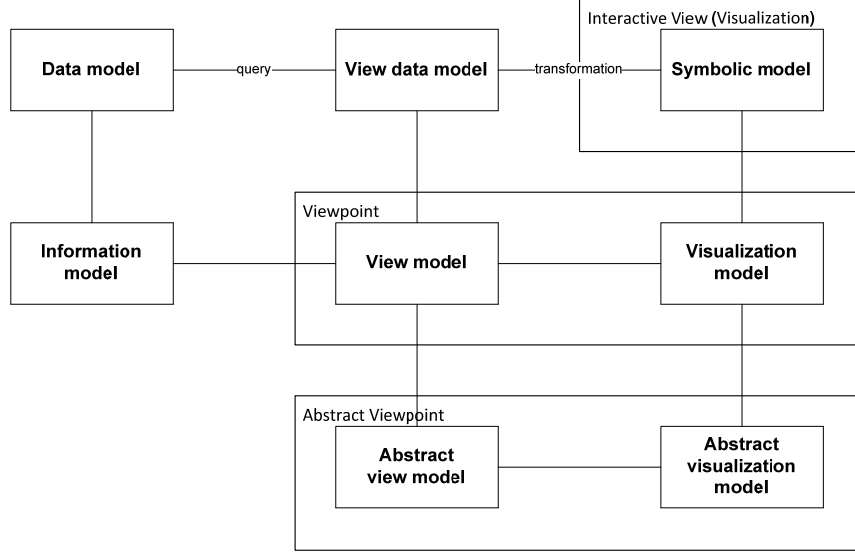


Figure 2. Overview of the conceptual framework for generating visualizations of arbitrary information models

This visualization model contains the primitives, e.g., rectangles, lines, colours, etc., and as such builds the schema for a particular symbolic model. With the abstract visualization model a set of more sophisticated preconfigured elements and symbols is placed at disposal. At runtime, an end-user configuration establishes the binding of abstract view model to abstract visualization model. This is done during instantiating an abstract viewpoint to a viewpoint. Due to space limitations, we omit the details of the framework and refer the interested reader to (Schaub *et al.*, 2012). The conceptual framework is exemplified based on a particular visualization from the V-Pattern 5 in (Buckl *et al.*, 2008).

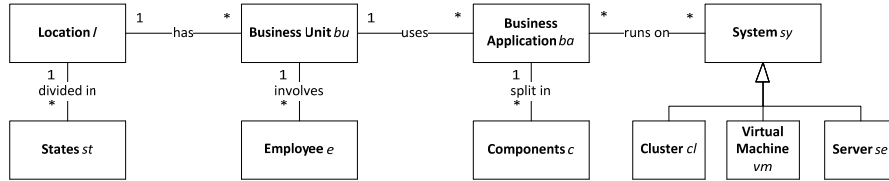


Figure 3. Exemplary enterprise specific information model

Figure 3 shows an excerpt of an exemplary information model of a specific enterprise. The model transformation for generative visualizations first selects relevant information entities based on the information demands, i.e. abstract view

model, of the visualization to find suitable view models of one particular information model. Then, possible mappings are enhanced with a pattern matcher (Bergmann *et al.*, 2008) for dynamically changing collaboration partners with deviating information models.

As aforementioned, the information demands for the visualization are captured with the abstract view model. An instance of such an abstract view model is shown in Figure 4 (a), whereas a respective generated cluster map is shown in Figure 4 (b). For generating visualizations based on an abstract view model, the abstract viewpoint binds it to an abstract visualization model while assigning variability points of visual symbols that may get used, i.e. elements of the abstract visualization model are not yet finally configured. For instance, in a cluster map, the inner symbol could also be a circle or the rectangle could have rounded edges. This allows an analyst to customize the visualization elements by configuring the abstract viewpoint.

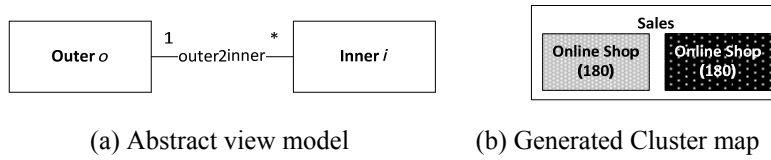


Figure 4. *Generated cluster map with the abstract view model*

It also specifies the properties of these symbols, e. g. colors to represent attributes or the shapes to be instantiated. A major benefit of an explicit modeled abstract view model is the recommendation of information model entities that can be mapped to the abstract view model. That means, users interested in visualizing certain aspects of the information models are supported with a list of matching entities for the inner and outer entities. Thereby, a pattern matching to arbitrary information models is necessary to recommend end-users possible data bindings, i.e. valid mappings, of abstract view model to information model to get a view model.

A possible mapping selects the **Location** l from the information model as **Outer** o and the **States** st or the **Business Units** bu as possible **Inner** i since both entities have a one-to-many relationship. In the same manner the **Business Unit** bu and the **Employee** e or the **Business Application** ba and the **Component** c can be mapped. Resulting tuples of a pattern matching are: [(o|l), (i|st)], [(o|l), (i|bu)], [(o|bu), (i|e)], [(o|bu), (i|ba)], [(o|ba), (i|c)]. More complex cases are possible with these abstract view model and information model, e.g. transitively: [(o|l), (i|ba)]. Since the abstract view model is based on a metameta-model of the Eclipse Modeling Framework, it is designed to be generic and can be matched against arbitrary information models from dynamically changing enterprises as occurring in collaborative business processes employing ontologies.

3. Outlook

In this paper we showed how an explicitly modeling of the information demands for an abstract viewpoint in terms of an abstract view model can cope with the problem of arbitrary changing information models. As a result of applying pattern matching techniques, we are able to 1) recommend valid data bindings to end-users, 2) generate visualizations of arbitrary information models, and 3) rebind to changed information models. We aim to discuss our findings in a workshop environment. Further work will focus on dynamically extending abstract view models for more complex visualizations. We observed a common behavior in dynamic abstract view models for certain abstract viewpoints. Example for this behavior can be found for instance in Sugiyama graphs and recursive clusters.

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